Influence of market rules for wind integration in the European power markets

Meibom, Peter; Weber, Christoph

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Peter Meibom, Risø DTU, Christoph Weber, University of Stuttgart,
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Content

- Market design and wind power
- Cases
- Wilmar model
- Results

MARKET DESIGN

PAST

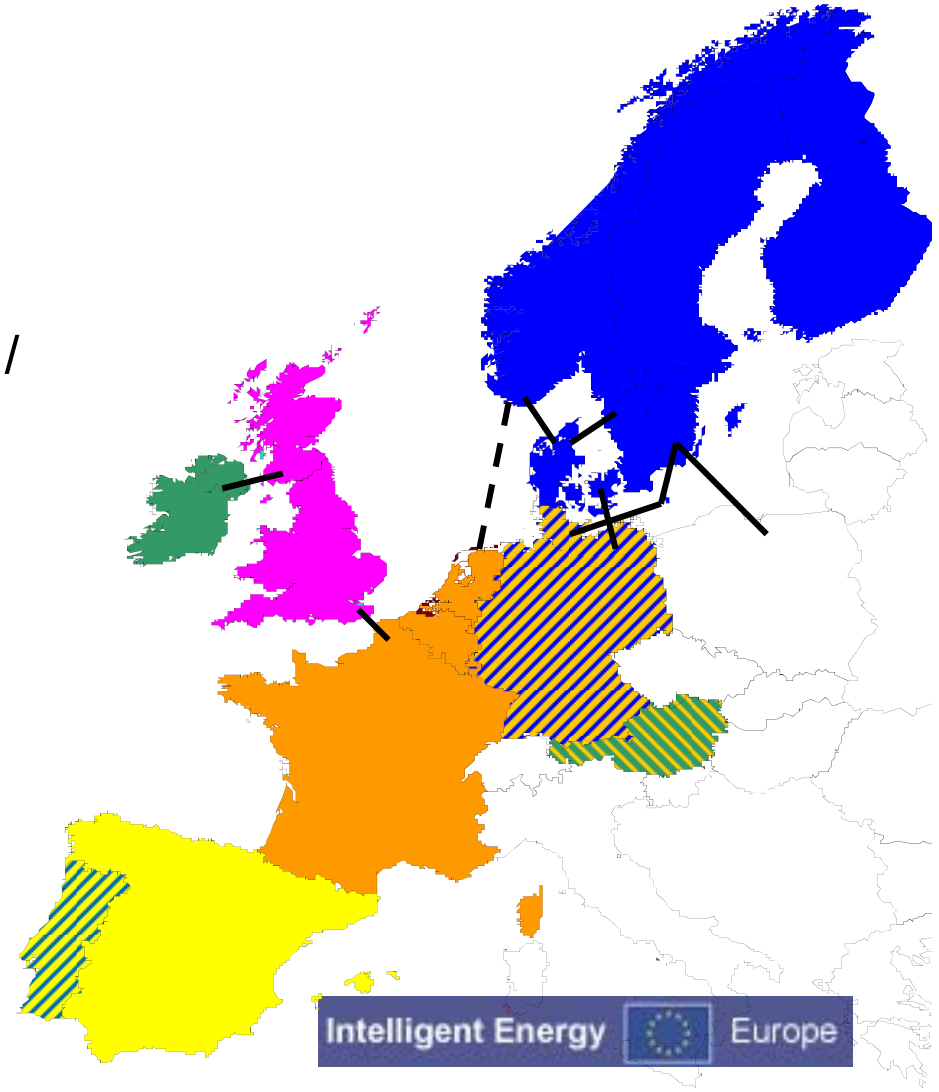
- Vertically integrated monopolies

PRESENT

- Unbundling: TSO vs. producers / suppliers
- Competition
- National – regional markets

FUTURE

- European integration
- Regional markets



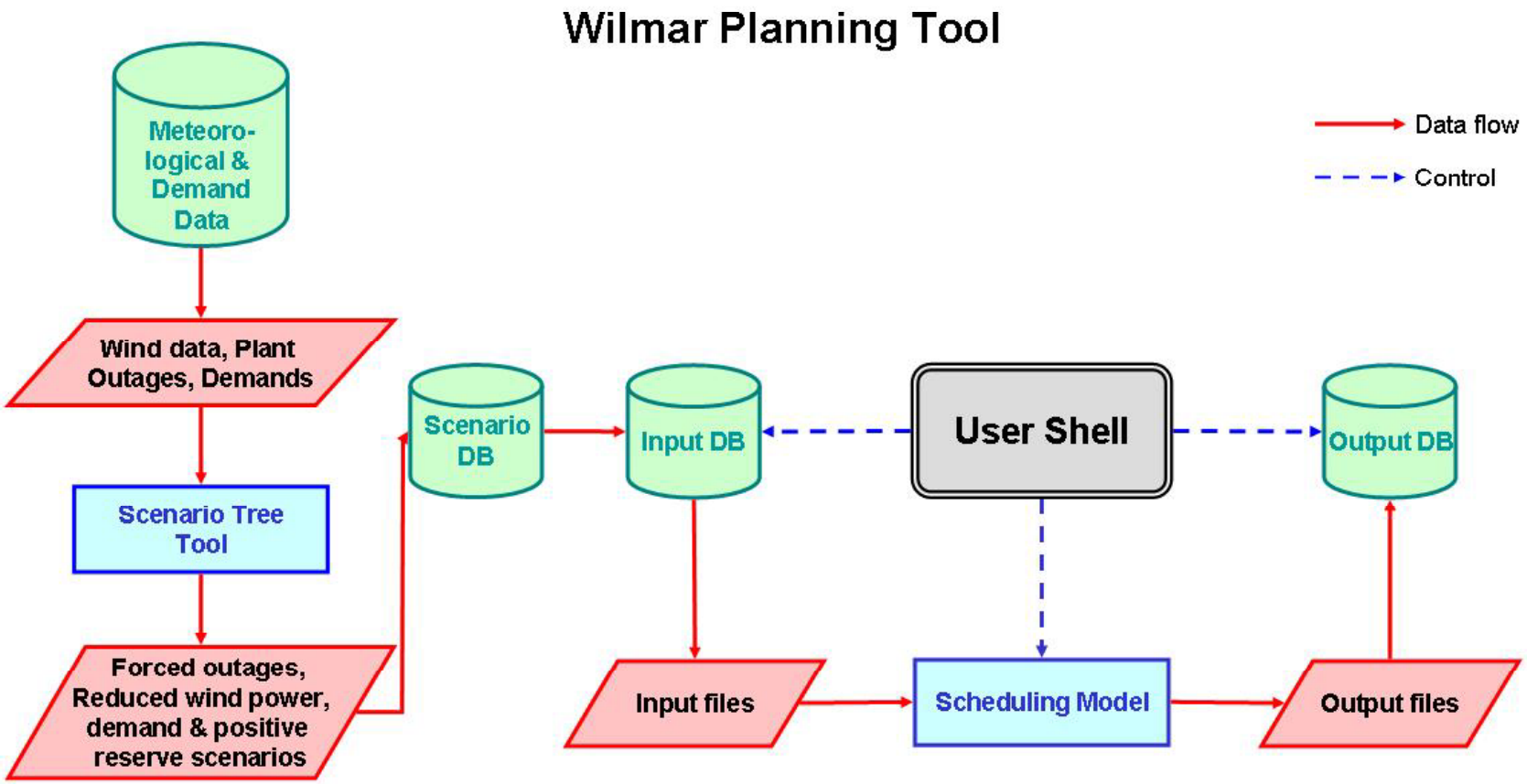
Market design and wind power

- Wind power adds variable and partly predictable power production:
  - Create higher demand for flexibility in the power system
- Market design should encourage the usage of available flexibility:
  - In cross-border exchange of power and reserves
  - In rescheduling of units

Wilmar Planning tool – Basic idea

- Improve operational decisions in power systems (unit commitment and dispatch of units) by using not only:
  - The expected value of wind power and load forecasts
  - But also accuracy of forecast, i.e. the distribution of forecast errors
- Approach:
  - Development of hourly system-wide stochastic optimisation model with stochastic input parameters
  - Covering both day-ahead scheduling and rescheduling due to updated forecasts
  - Rolling planning to take updated forecasts into account
- Consequence: Model makes unit commitment and dispatch decisions being robust towards forecast errors

Components of Wilmar Planning Tool



Scheduling model

- Stochastic, mixed integer, linear optimisation model
- Stochastic input in the form of a scenario tree
- Stochastic input:
  - Wind power production forecasts (dispatch)
  - Electricity demand forecasts (dispatch)
  - Forecasts of demands for replacement reserves (unit commitment)
- Replacement reserve: demand for positive reserves that replaces spinning reserves (activation times above 5 minutes):
  - Demand dependant on forecast horizon (forecast horizons from 5 minutes to 36 hours ahead)
  - Demand dependant on wind power and load forecasts

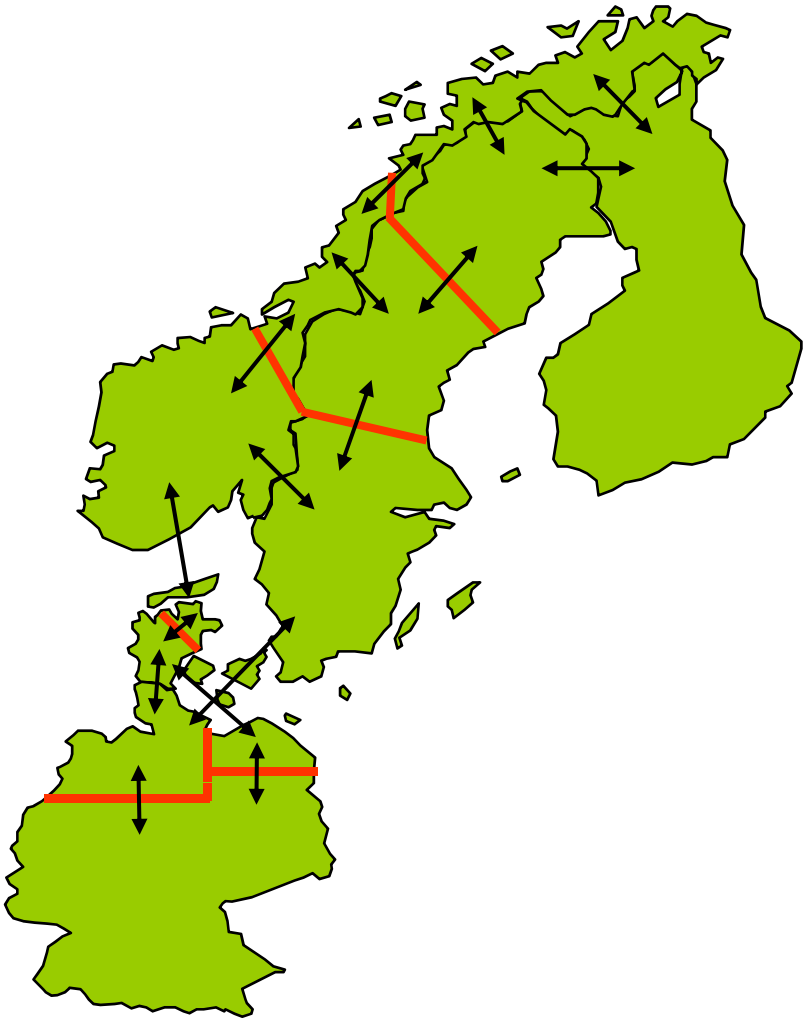
Scheduling model

- Optimisation over all outcomes represented by the scenario tree taking both demands for electricity and demand for spinning and replacement reserves into account
- Minimisation of expected costs. Expectation taken over branches in scenario tree
- **Unit restrictions:** minimum up time, minimum down time, start-up time, minimum stable operation level, piece-wise linear fuel consumption curve, restriction on ability to provide spinning reserve
- Model representation of:
  - Thermal units: condensing, combined heat and power
  - Heat boilers, heat pumps, heat storages
  - Electricity storage
  - Plug-in electric vehicles
  - Transmission grid

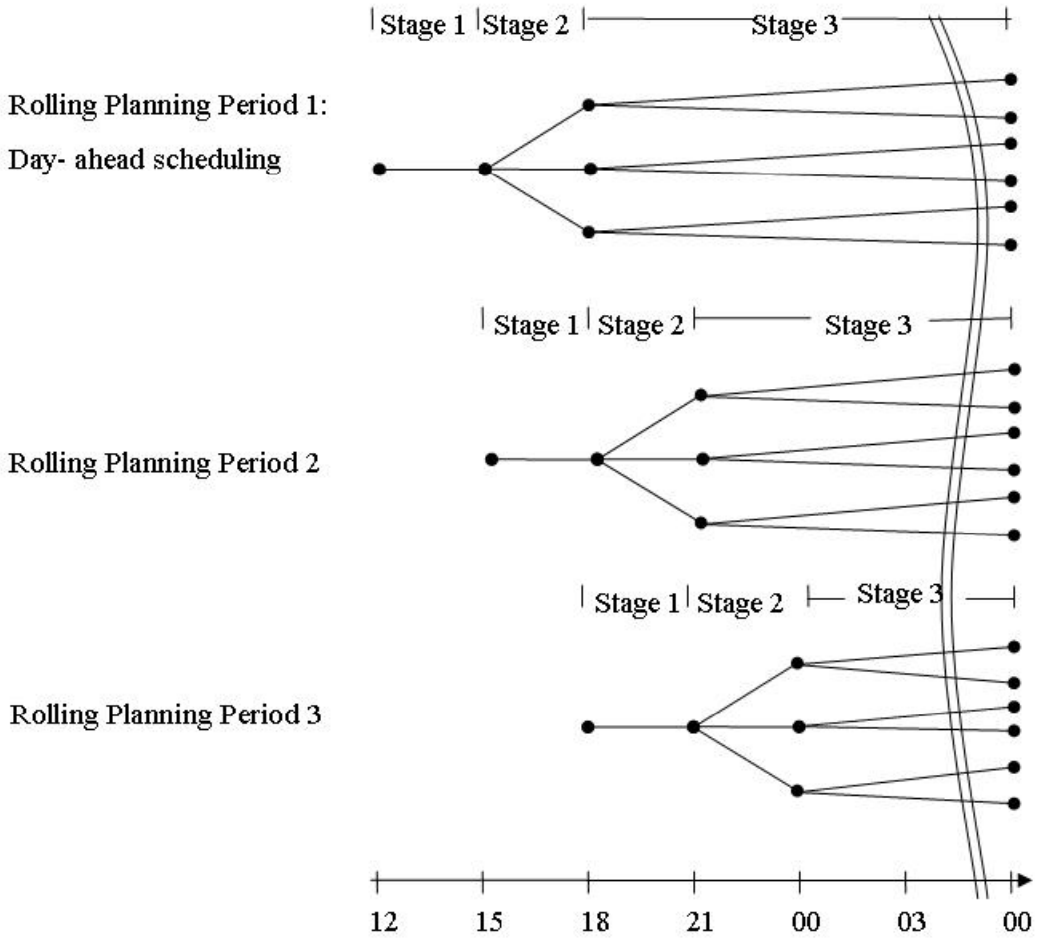
Overview of the Planning Tool

Subdivision of the modelled area into model regions to consider:

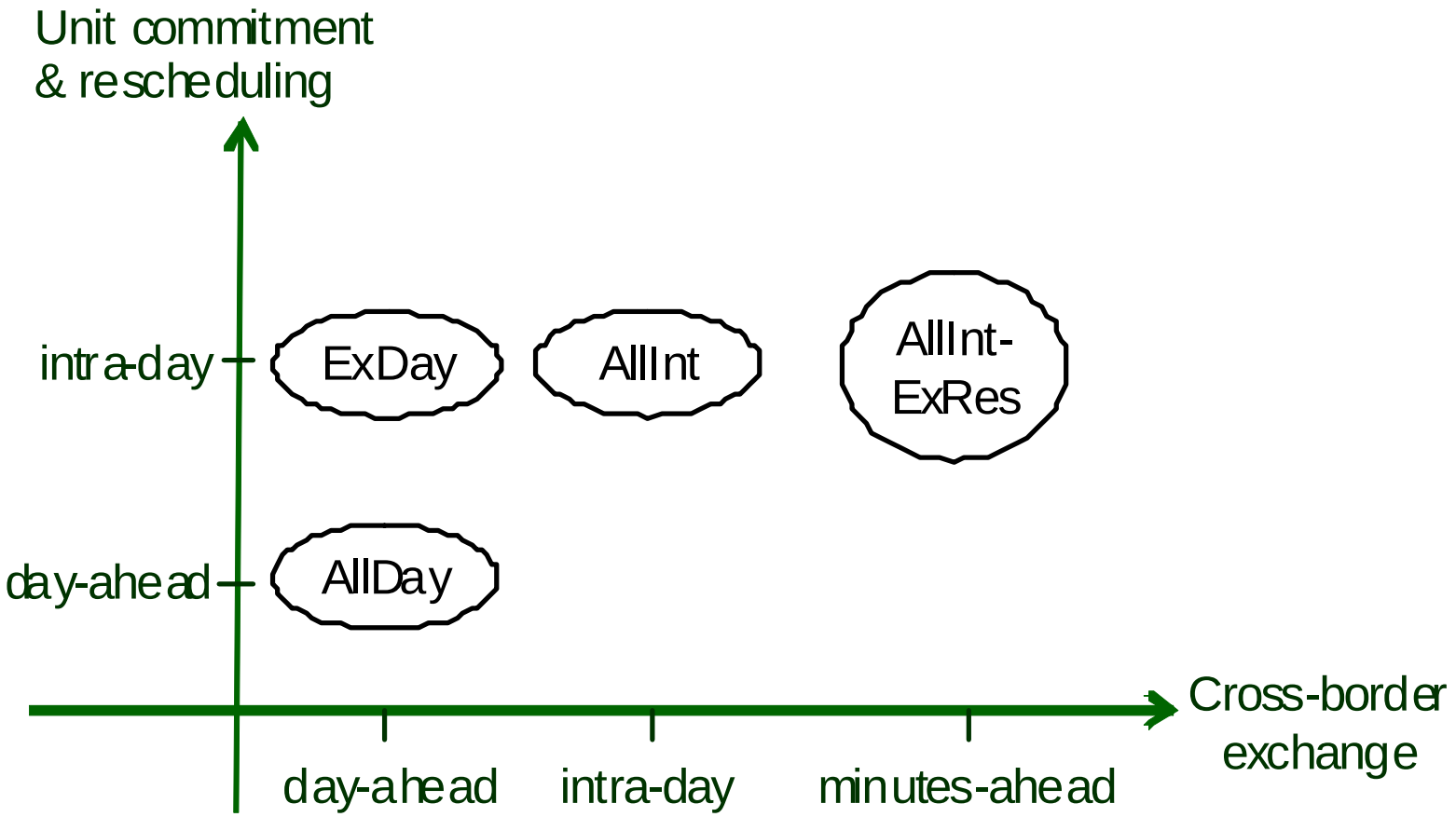
- Spatial concentration of the installed wind power
- Spatial distribution of the electrical demand
- Bottlenecks in the transmission grid



Rolling planning: rescheduling due to updated forecasts



Overview market rule cases



Overview cases

- **AllDay:** Unit commitment for slow units and power exchange over borders determined day-ahead (12-36 hours ahead) and not rescheduled intra-day.
- **ExDay:** Like AllDay except for unit commitment for slow units now being rescheduled intra-day. Cross-border exchange is still allowed day-ahead only.
- **AllInt:** Like ExDay but power exchange allowed to be rescheduled intra-day.
- **AllIntExRes**: Like AllInt but exchange of replacement reserves across borders allowed, i.e. part of the demand for replacement reserves can be provided by a neighbouring country by reserving part of the cross-border transfer capacity for this purpose.

Cases

- Two target years 2020 and 2030
- 4 market rule cases for each target year
- 25 European countries included in model
- Only one region per country
- Hourly resolution
- Treat combined heat and power plants as power plants producing only power

Data input

- Electricity demand is based on empirical hourly load data for 2006 extrapolated to 2020 and 2030

Fuel prices per fuel type for power generation in Euro 2005 per MWh primary energy.

€05 / MWh	**2020**	**2030**
Oil	28.8	29.6
Gas	21.7	22.4
Coal	6.9	7.0
Biomass	16.2	16.2
Nuclear	5	5

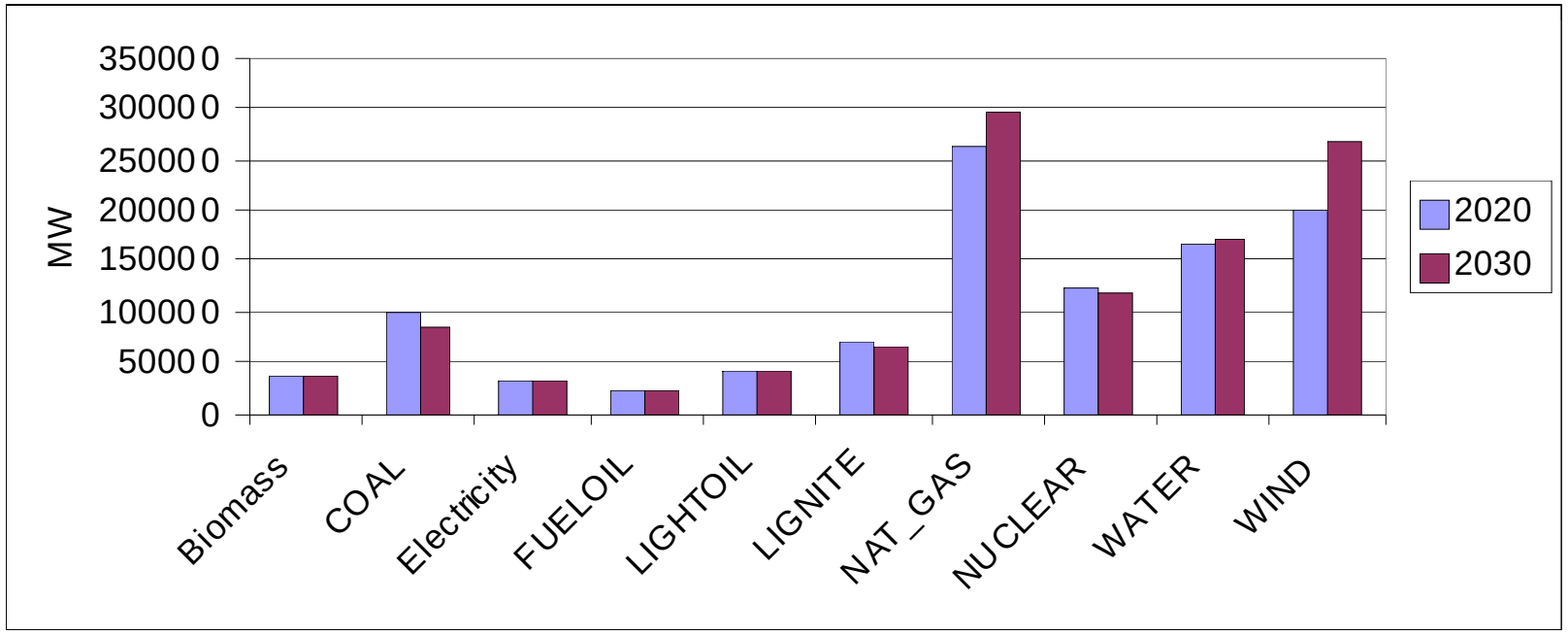
Prices for tradable CO_2 emission allowances in Euro 2005 per tonne CO2.

€05/tonne	**2020**	**2030**
CO2	22	24

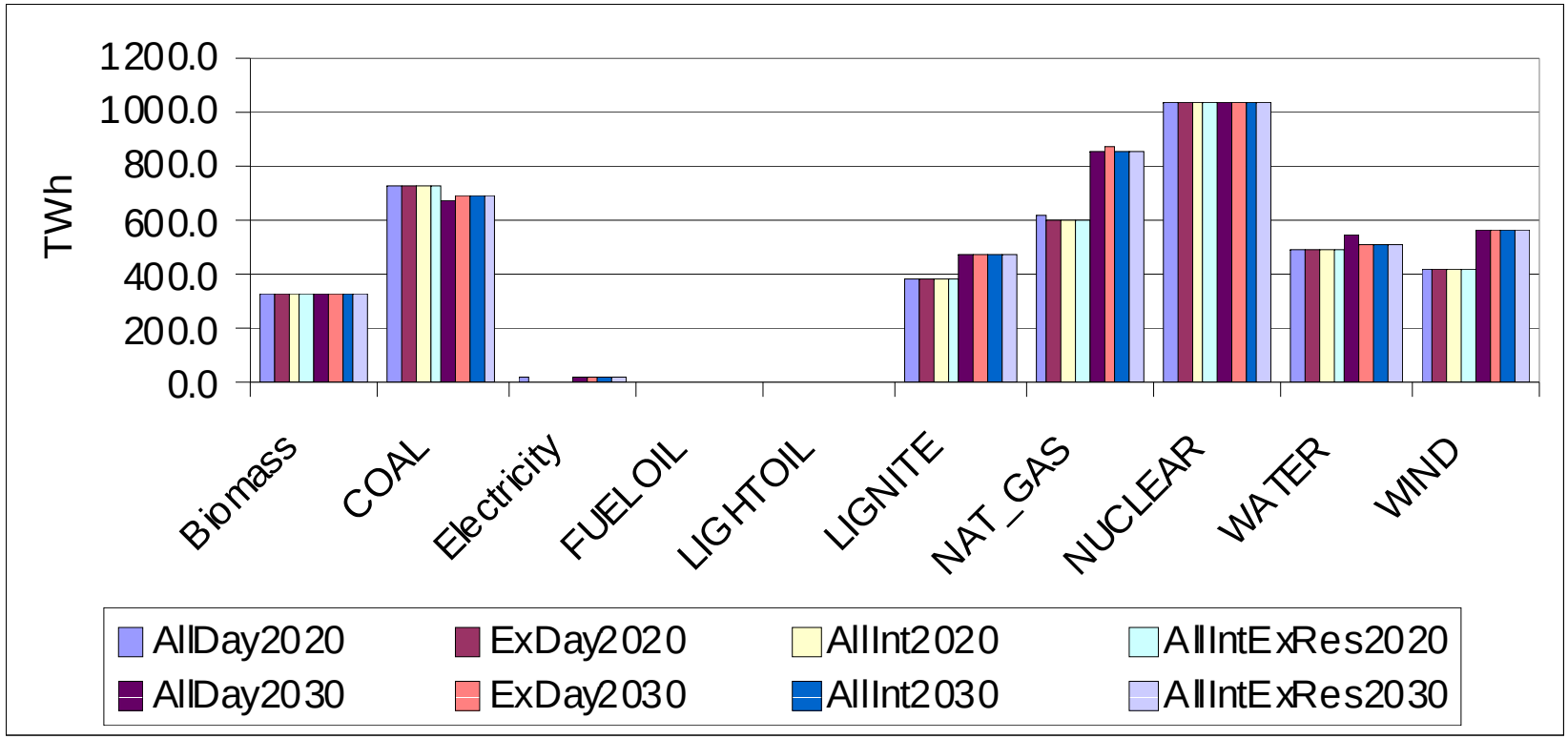
Data input

- Development in installed capacities of power plants taken from UCTE, System Adequacy Forecast 2007-2020
- Cross-border capacities constructed from net transfer capacity data of today supplemented by grid reinforcements that are currently in the realisation or planning phase

Installed capacity distributed on fuels in 2020 and 2030 for all cases



Yearly electricity production distributed on fuels in 2020 and 2030



Wind power production 10.5% of electricity consumption in 2020 and 12.5% in 2030

Operational costs 2020

All values in MEuro	AllDay2020	ExDay2020	AllInt2020	AllIntExRes2020
System costs	103302	103151	102732	102675
VOLL	4479	320	73	91
Cost not meet replacement reserve target	74	29	5	4
Cost not meet spinning reserve target	471	24	2	2
Total	108326	103524	102812	102772
Difference relatively to ExDay	-4802	0	712	752
Relative to ExDay	1.05	1.00	0.99	0.99

VOLL (Value of lost load) set to 3000 Euro/MWh

Costs of not meeting reserve targets set to 300 Euro/MWh

Operational costs 2030

	AllDay2030	ExDay2030	AllInt2030	AllIntExRes2030
System costs	118163	119705	119046	118952
VOLL	7822	807	116	171
Cost not meet replacement reserve target	101	55	16	15
Cost not meet spinning reserve target	514	42	11	10
Total	126600	120608	119188	119148
Difference relatively to ExDay	-5992	0	1420	1460
Relative to ExDay	1.05	1.00	0.99	0.99

VOLL (Value of lost load) set to 3000 Euro/MWh

Costs of not meeting reserve targets set to 300 Euro/MWh

Conclusions

TIME AND SPACE DIMENSION

- Intra-day rescheduling of unit commitment absolutely necessary

- Intra-day rescheduling of cross-border exchange
  - system costs savings: 1-2 bn €/yr (1%)

- Coss-border exchange of reserves:
  - very slight effect: 40 M€/yr (0.04%)
  - differences in reserve capacity requirements per country

Recommendations

FLEXIBILITY OF POWER PLANTS

- slower power plants to participate in intra-day reschuling
- *slow* meaning start-up time > 1h

INTERNATIONAL DIMENSION

- allow intra-day rescheduling of interconnectors
- establish cross-border intra-day markets
- pursue the regional markets initiative

RESERVE POWER EXCHANGE

- yields savings in investment rather than system cost
- investigate trade off between national investments and international exchange

Recommendations

CONGESTION MANAGEMENT

- replace explicit auctioning with implicit auctioning of interconnectors